Computer-related posture and discomfort in primary school children: The effects of a school-based ergonomic intervention

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ABSTRACT

This study investigated the effect of a school-based ergonomic intervention on children's posture and discomfort while using computers using a pre/post test study design. The sample comprised 23 children age 9 and 10 years. Posture was assessed with Rapid Upper Limb Assessment (RULA) and a workstation assessment was completed using a Visual Display Unit (VDU) checklist. Self-reported discomfort was also recorded at the beginning and end of the computer class. Following an ergonomic intervention that included education of the children and workstation changes, the outcome measures were repeated. There was a positive response to the intervention with significant changes between the pre-intervention and post-intervention scores for posture ($p = 0.00$) and workstation ($p = 0.00$). The change in discomfort scores from beginning to end of the computer class between the pre-intervention class and the post-intervention class was also significant ($p = 0.00$). The study highlights the need for continuing concern about the physical effects of children's computer use and the implications of school-based interventions.

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1. Introduction

The use of computers in schools is now well established worldwide and strategies to increase the level of use of computers by children are ongoing. The implementation of information technology (IT) in schools continues apace as educational institutions are increasingly looking at the use of IT in the development of new teaching and learning models. A recent study by McMahon (2009) found a statistically significant correlation between students' computer skills and their level of critical thinking. He advocates that IT should be integrated across all learning areas in school to facilitate the development of higher order thinking skills. The use of information technology in schools and the factors that influence or contribute to its use have been investigated (Albirini, 2006; Baek, Jung, & Kim, 2008; Haydn & Barton, 2008). However, there continues to be little thought given to ergonomic factors during the setting up of computer workstations in schools or to the subsequent use of the computers by the children. There also continues to be concern about the short and long term physical effects that poor ergonomic workstation design and use of the computers can have on children. Previous research has highlighted the mismatch between the size of the computer workstations and the size of primary school children (Noro, Okamoto, & Kojima, 1997), and further research has identified poor user-workstation dimensions (Bergqvist, Sotoyama, & Piccolic, 1997; Zandvliet & Straker, 2001). McGrail (2007) reported that the physical classroom environment, such as space and furniture, played a significant part in the negative outcomes of computer use in school.

The benefits of educational technologies in terms of student learning, classroom organisation and curriculum development should be complemented by effective, safe and productive use of computers by schoolchildren. Ergonomics as a discipline, addresses these factors, but there are few studies to date that examine ergonomic issues related to computer use in schools.

1.1. Intervention studies

Studies have investigated the effects of an intervention on various aspects of computer use by children. Studies have been laboratory-based (Laeser, Maxwell, & Hedge, 1998; Straker, Briggs, & Grieg, 2002) home-based (Williams & Jacobs, 2002) or school-based (Cardon, De
Clercq, & De Bourdeaudhuij, 2000; Geldhof, Cardon, De Bourdeaudhuij, & De Clercq, 2006; Rowe & Jacobs, 2002). Some positive outcomes of ergonomic interventions in children have been demonstrated. The outcome measures included knowledge (Cardon et al., 2000; Geldhof et al., 2006; Rowe & Jacobs, 2002; Shinn, Romaine, Casimano, & Jacobs, 2002; Williams & Jacobs, 2002) and behaviour (Geldhof et al., 2006; Williams & Jacobs, 2002). Interventions have comprised a single session of verbal instruction and demonstration (Williams & Jacobs, 2002), a 12-min education session (Rowe & Jacobs, 2002), a 6-week back care education programme (Cardon et al., 2000), and a 2-year multifactorial intervention (Geldhof et al., 2006).

Williams and Jacobs (2002) carried out a home-based education intervention and investigated its effects on knowledge and sitting posture of six children (mean age 12.7) and their parents. They concluded that knowledge of ergonomically correct computer use improved but that sitting posture did not improve following the intervention. Rowe and Jacobs (2002) in a school-based 12-min intervention programme with 19 children (mean age 11.6) reported that the intervention improved knowledge of correct computing habits. Similarly, Shinn et al. (2002) found that ergonomic knowledge can increase as a result of a school-based education intervention. They mention that the environment should also improve to allow the children to put what they have learned in the education session into practice.

Geldhof et al. (2006) investigated the effects of a school-based back education programme on 193 children who were 9–11 years old. The study also included 172 controls. They reported that the children’s back posture knowledge and observed postural behaviour improved as a result of the intervention, but there was no effect on back and neck pain in girls, although there was a trend for decreased pain among the boys. They concluded that back posture education as part of the school curriculum was an effective way to teach back care to children.

With these issues in mind, the current study set out to investigate the effect of an ergonomic intervention on the posture and discomfort of school children. Some aspects of the intervention were similar to other studies in that it was educational in nature and was school-based, as this has been recommended by previous authors (Geldhof et al., 2006). In addition to the educational intervention, the current study included the assessment of the changes implemented to the workstations that were used by the children in school so that they could put their new knowledge into practice.

1.2. Aims and objectives

The main aim of the study was to assess the effect of an ergonomic intervention on the posture and discomfort of primary school children while working at computers in school. The objectives were to: (1) assess primary school children’s posture at a computer; (2) record discomfort levels before and after computer use; (3) assess computer workstations; (4) plan and implement an intervention programme; (5) compare posture pre and post-intervention; (6) compare the levels of discomfort pre and post-intervention; and (7) compare computer workstations pre and post-intervention.

2. Method

2.1. Research design

A pretest–posttest design was used and was conducted in three stages. The pre-intervention or baseline stage involved the assessment of the children as they worked at the computers and the assessment of the computer workstations in the school. The intervention stage consisted of the ergonomic intervention which included education and advice for the children and their teacher, introduction of new work practices based on current ergonomic advice, and changes to the workstations as required. The post-intervention stage involved a follow-up assessment of the children as they worked at the computers and the assessment of the computer workstations in the school in order to ascertain if there was any difference between the pre and post-intervention stages. This methodology was used to evaluate the impact of the ergonomic intervention.

2.2. Ethical approval, consent and assent

Ethical approval was granted by the Trinity College Dublin Health Sciences Faculty Research Ethics Committee. The school principal and board of management were approached to obtain permission to carry out the study in the school. The class (4th) was chosen for participation in the study. A meeting was arranged with the class teacher to seek informed co-operation with the study. Information sheets and written assent and consent forms for the potential participants and their parents/guardians were distributed by the class teacher. Completed assent and consent forms were returned to the teacher and subsequently to the researchers.

2.3. Tools

2.3.1. Rapid Upper Limb Assessment (RULA)

Posture was evaluated using RULA (Rapid Upper Limb Assessment) which was developed by McAtamney and Corlett (1992). RULA is an observation method of posture analysis. It involves the allocation of a numerical score to an observed posture of different body parts (upper arms, lower arms, wrist, neck, trunk and legs). The posture scores are calculated and combined with a score for static muscle load and force,

<table>
<thead>
<tr>
<th>Action Level</th>
<th>Grand Score</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 or 2</td>
<td>Posture is acceptable if not maintained</td>
</tr>
<tr>
<td>2</td>
<td>3 or 4</td>
<td>Further investigation needed. May need changes</td>
</tr>
<tr>
<td>3</td>
<td>5 or 6</td>
<td>Further investigation and changes needed soon</td>
</tr>
<tr>
<td>4</td>
<td>7 or more</td>
<td>Investigation and changes required immediately</td>
</tr>
</tbody>
</table>
if appropriate, to give a Grand Score. The Grand Score is then used to identify the action that is indicated for that individual as shown in Table 1. A low RULA score is an indication of good posture.

2.3.2. Body Discomfort Chart and Visual Analogue Scale

The reported body discomfort was recorded on a Body Discomfort Chart (Corlett & Bishop, 1976) and a Visual Analogue Scale (Huskisson, 1982). The Body Discomfort Chart (BDC) consists of an outline drawing of the human body on which a person can mark the area that he or she feels discomfort. The Visual Analogue Scale (VAS) is a horizontal ten centimetre line on which a person marks his or her level of discomfort. One end of the line represents ‘no pain’ and is given a numerical score of 0 and the other end of the scale represents ‘the worst pain ever’ and is given a numerical score of 10. The VAS is frequently used in research and clinical settings to assess a person’s perception of pain or discomfort, and has been found to be reliable for use by children (Adams, 1990; McGrath, 1990).

2.3.3. Visual Display Unit (VDU) workstation checklist

The workstations were assessed with a modified Health & Safety Executive (UK) VDU workstation Checklist (Health & Safety Executive, 2003). The original checklist contains 32 items. The modification included the omission of some specific questions about text size and stability and a question about suitability of software, and the addition of questions relating to the desk and chair. The modified version contained 30 questions. The checklist had a total score of 30 and was subdivided into three individual categories: ‘computer’ (scored out of a maximum of 11), ‘furniture’ (scored out of a maximum of 14) and ‘environment’ (scored out of a maximum of 5). A scoring system was developed for the checklist, where a score of 30 was the maximum mark and also indicated the best score.

2.4. Reliability and validity

Reliability of RULA and the workstation checklist was established by independent and simultaneous assessment by two raters. All assessments took place on site in the school using a different cohort of children (n = 5) under normal school conditions and during normal school hours to ensure high external validity. Firstly the percentage (%) level of agreement between the two raters was reported. The average% agreement for the RULA Grand Score was 97% (range 83–100%). The average% agreement for the Action Level scores was 100%. The average% agreement for the Total VDU checklist was 96% (range 86–100%). Weighted kappa coefficients were also calculated to quantify level of agreement between the raters. Kappa is a measure of agreement between two different tests or raters. It was used here to measure the level of observed agreement beyond chance as a proportion of the potential agreement beyond chance in the two raters. This measure of agreement is commonly used to represent categorical data (Altman, 1991). The score ranges from 0 for no agreement beyond chance to 1 for perfect agreement beyond chance. The weighted kappa score for the RULA Grand Score was 0.8, the Action Level score was 1.0 and 0.6 for the VDU workstation checklist scores.

2.5. Procedure

2.5.1. Pre-intervention

The pre-intervention stage took place in January 2008. Each child completed a BDC and a VAS scale immediately before (BDC/VAS 1) and after (BDC/VAS 2) their computer class. The duration of the computer class was approximately 20 min, which is fairly typical for school-children of this age (Dockrell, Fallon, Kelly, Masterson, & Shields, 2007). Separate sheets were used for the ‘before’ and ‘after’ conditions so that the participants were not influenced by what they had written previously. Posture was evaluated on site by the researchers using RULA (Rapid Upper Limb Assessment). Participants were assessed on three occasions during the computer class, at the beginning, halfway through and towards the end of the class. The workstations were assessed once during the time the participants were working at them.

2.5.2. Intervention

The intervention was carried out in April 2008. The intervention was specific, and based on the findings of the pre-intervention assessments. The intervention was aimed at the promotion of good posture and good work practices in keeping with current research and best practice. It comprised two phases. The first phase involved a 1 h interactive learning session for the children. The class teacher attended the session. The information was given using a Power Point presentation and the children were required to participate in various examples. A problem solving approach was used where the children were asked to identify correct and incorrect postures from photo images of themselves taken at the pre-intervention stage. The specific tasks that the children were performing on the computers were discussed in the session. The correct postures and the reasons why they were correct were discussed. The importance of comfort while sitting at the computer and the need for frequent breaks were also emphasised. At the end of the session the children completed a quiz on the material that was presented during the session. Each child also drew a poster entitled “good posture at the computer” after the session under the supervision of the teacher. Some of the posters were subsequently displayed in the computer workstation area.

The second phase consisted of identifying areas that required change based on the workstation assessments and implementing a series of changes to the workstations. Changes included the provision of flat screen monitors and mouse pads, and the removal of unnecessary items from the desk. Clutter was removed from under the desks allowing greater leg room to facilitate good posture and also greater ease of ingress and egress. See Table 4 for details of the findings and required changes recorded for one of the workstations.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>SE</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-intervention</td>
<td>Grand RULA</td>
<td>21</td>
<td>5.9</td>
<td>0.9</td>
<td>6.3</td>
<td>0.19</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Post-intervention</td>
<td>Grand RULA</td>
<td>22</td>
<td>4.1*</td>
<td>0.7</td>
<td>4</td>
<td>0.15</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

* P < 0.00 difference between pre-intervention and post-intervention Grand RULA score.
2.5.3. Post-intervention

The post-intervention stage took place in June 2008, ten weeks after the completion of the intervention. This length of time was chosen as it was deemed to be a reasonable period of time post-intervention to assess the sustained impact of the intervention, but not so long as to be affected by growth spurts in the participating children. The pre-intervention assessments were repeated at this stage. The same methodology was followed. Each child was assigned to the same workstation and assessed by the same researcher as in the pre-intervention stage in order to improve the reliability of the results. Each child completed a BDC and VAS (BDC/VAS 3) immediately before the computer class and completed a further one (BDC/VAS 4) after the computer class.

2.6. Analysis of data

All data were entered into Excel. All data were cross checked by an independent person who was not involved in the study. Descriptive statistics were primarily used to represent the demographic details of the children. A non parametric Wilcoxon signed rank test and Mann–Whitney U test were used to ascertain if there was a difference within or between groups in the various outcome measures. Minitab (version release 13.1) statistical package was used for the data analysis.

3. Results

3.1. Demographics

Twenty-three school children participated in the study. All children were in fourth class and were aged between 9 and 10 at the time of the study. Fifteen children were female and eight were male. Informed consent was obtained from the parents/guardians and informed assent was obtained from the children prior to involvement in the study. Two females were excluded from further analysis in the pre-intervention stage due to the reporting of high levels of pain. One of these was also excluded from the analysis in the post-intervention stage for the same reason.

3.2. RULA scores

RULA scores were calculated at three different time periods during the class and an average of the three scores was taken. There was no significant difference in the Grand RULA score recorded at the different time points in the pre-intervention class. The average Grand RULA score (G-RULA 1) in the pre-intervention class was 5.9 ± 0.9. There was no significant difference in the Grand RULA scores of the children who did and did not report discomfort at the end of the pre-intervention class ($p = 0.74$). The average Grand RULA score (G-RULA 2) in the post-intervention class was 4.1 ± 0.7. There was no significant difference in the recorded Grand RULA scores at the different time points in the post-intervention class. Furthermore, there was no significant difference in the scores of the children who did and did not report

\[ P < 0.05 \text{ difference between VAS scores before and after the pre-intervention class.} \]

### Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>SE</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS 1</td>
<td>21</td>
<td>0.9</td>
<td>1.5</td>
<td>0</td>
<td>0.33</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>VAS 2</td>
<td>21</td>
<td>1.8</td>
<td>1.5</td>
<td>2</td>
<td>0.32</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>VAS 3</td>
<td>22</td>
<td>1.5</td>
<td>2.1</td>
<td>0</td>
<td>0.45</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>VAS 4</td>
<td>22</td>
<td>2.2</td>
<td>2.2</td>
<td>2</td>
<td>0.46</td>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

* $P < 0.05$ difference between VAS scores before and after the pre-intervention class.

### Table 4

Findings and suggested changes for one workstation.

<table>
<thead>
<tr>
<th>Workstation</th>
<th>Present situation</th>
<th>Ideal situation</th>
<th>Minimum acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimberly</td>
<td>Monitor and keyboard on a fixed shelf</td>
<td>Total review of layout of seating arrangement for computer workstations</td>
<td>• Use chair type (blue or green) dependant on stature of operator</td>
</tr>
<tr>
<td></td>
<td>The shelf is very narrow</td>
<td>Fully adjustable operators chair (seat height, back height and tilt, arm rests – up/down and in/out, seat pan.</td>
<td>• Flat screen monitor</td>
</tr>
<tr>
<td></td>
<td>Box style monitor in situ</td>
<td>Replacement of mouse pad</td>
<td>• Seek three cushion sizes for operators usage to raise them up to appropriate height</td>
</tr>
<tr>
<td></td>
<td>The monitor and keyboard are rotated to the right</td>
<td>Document holder</td>
<td>• Provision of document holder</td>
</tr>
<tr>
<td></td>
<td>A smaller of the chair types is located here (blue frame) which does not have adjustable seat height, back height or tilt adjustment.</td>
<td></td>
<td>• Replace mouse pad</td>
</tr>
<tr>
<td></td>
<td>Mouse pad is in bad state of repair</td>
<td>No document holder in situ</td>
<td>• Review locations of electrical sockets and requirement for additional sockets</td>
</tr>
<tr>
<td></td>
<td>No document holder in situ</td>
<td>No foot rest in situ</td>
<td>• Relocate hard drive to allow for more leg room</td>
</tr>
<tr>
<td></td>
<td>Overloading of sockets</td>
<td>Overloading of sockets</td>
<td>• Tidy up bench (above and below)</td>
</tr>
<tr>
<td></td>
<td>The hard drive is positioned on the left of the operator allowing for little leg room under bench. This workstation backs directly onto another workstation with very limited manoeuvrability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.5.3. Post-intervention

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3.2. RULA scores

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discomfort at the end of the post-intervention class ($p = 0.38$). A Wilcoxon signed rank test was calculated to determine if the difference in Grand RULA scores between pre and post-intervention assessment was significant. The change in scores between the pre-intervention class and the post-intervention class was significant ($p = 0.00$). A summary of the Grand RULA scores is contained in Table 2.

The mean RULA C score (upper limb) in the pre-intervention class was 4.8 ± 0.8. The mean RULA C score in the post-intervention class was 3.8 ± 0.5. This change in score was also significant ($p = 0.00$). The mean RULA D score (neck, trunk, leg) in the pre-intervention class was 5.7 ± 1.0. The mean RULA D score in the post-intervention class was 3.9 ± 0.9. This change in score was significant ($p = 0.00$). There was no significant difference in the RULA Grand Scores between male and female children in the pre or post-intervention classes.

3.3. Action Levels

The RULA Grand Score is used to allocate the person’s posture into an Action Level. See Table 1. The mean Action Level score was 3.0 ± 0.5 in the pre-intervention class. The mean Action Level score in the post-intervention class was 2.1 ± 0.3. This change in score is statistically significant ($p = 0.00$). It is also clear from Fig. 1 that there is a shift into the lower Action Levels in the post-intervention class.

3.4. Body discomfort

Eight children reported discomfort on the Body Discomfort Chart (BDC) at the beginning of the pre-intervention class (VAS 1). Three children reported back pain, one reported neck pain and four reported pain in the lower limb. The intensity of reported pain was measured on the 10 point VAS scale. Two children reported a back pain intensity of eight and ten respectively at the beginning of the pre-intervention class and thus were excluded from analysis. The mode response of the remaining 21 children was 2/10. The range of reported pain was 0–5 on the VAS scale. The mean intensity of pain reported was 0.9 ± 1.5. Fourteen children reported pain after the class (VAS 2). The most common area of reported pain was back pain ($n = 4$). The mean intensity of pain reported by children after the class was 1.8 ± 1.5. A Wilcoxon signed rank test was calculated to ascertain if there was a difference between pre and post class scores. There was a significant difference between the intensity of reported pain by children before and after the class ($p = 0.04$).

Nine children reported discomfort on the BDC at the beginning of the post-intervention class (VAS 3). One child reported that the pain in her arm was 8/10 on the VAS scale and was excluded from further analysis. Two children reported back pain. Other areas of reported pain included the neck ($n = 2$) and lower limb ($n = 4$). The intensity of pain reported by children ranged from 0 to 5 on the VAS scale. The mode response was five. The average intensity of pain reported was 1.5 ± 2.1. Fourteen children reported pain after the post-intervention class (VAS 4). Five children reported back pain. Other areas of reported pain included the neck ($n = 3$) and lower limb ($n = 6$). The mean intensity of pain reported by children at the end of the class was 2.2 ± 2.2. There was no significant difference between the intensity of reported pain in children before and after the class ($p = 0.21$). This is evident from Fig. 2. The descriptive statistics for all reported VAS scores are displayed in Table 3. There was no significant difference in reported pain at the beginning of the pre and post-intervention classes ($p = 0.49$) or at the end of the pre and post-intervention classes ($p = 0.76$). Furthermore, there was no significant difference in the intensity of pain reported by males and females at the end of the pre and post-intervention classes.

3.5. VDU checklist

The checklist had a total score of 30 and was subdivided into three individual categories as outlined in Section 2.3.3. The mean total score for the VDU checklist was 14.1 ± 1.4 in the pre-intervention class. The mean total score in the post-intervention class was 16.8 ± 2.8. There was a significant difference in the pre and post-intervention scores ($p = 0.00$). The mean score for the ‘computer’ section of the VDU checklist was 5.9 ± 0.9 in the pre-intervention class. In the post-intervention class, the mean score was 7.0 ± 1.8. There was a significant difference in the documented mean ‘computer’ VDU scores between the pre and post-intervention class ($p = 0.0262$). The mean score for the ‘furniture’ section of the VDU checklist was 3.9 ± 0.9 in the pre-intervention class. In the post-intervention class, the mean score was 5.3 ± 1.2. There was a significant difference in the documented mean ‘furniture’ VDU scores between the pre and post-intervention class ($p = 0.00$). The mean score for the ‘environment’ section of the VDU checklist was 4.4 ± 0.5 in the pre-intervention class. In the post-intervention class, the mean score was 4.6 ± 0.5. There was no significant difference in the documented mean ‘environment’ VDU scores between the pre and post-intervention class ($p = 0.37$).
There was no significant difference in the VDU Checklist total scores of the children who did and did not report discomfort and the end of the pre-intervention class \((p = 0.10)\) or at the end of the post-intervention class \((p = 0.31)\). Finally, there was no significant difference in the total VDU scores of male and female children in the pre and post-intervention classes.

4. Discussion

This study aimed to assess the effect of an ergonomic intervention on the posture and discomfort of school children as they used computers in school. A secondary aim was to assess the effect of the intervention on the computer workstations. Overall, the children's posture at the computers was not optimal, there were high levels of 'low intensity' discomfort and the equipment and workstation design were poor.

4.1. Posture

One of the key components of the study was the use of the RULA assessment tool to measure the children's posture at the computer workstations. Our results indicate that the mean RULA score for posture was significantly better post-intervention when compared to the pre-intervention score. The mean RULA C and D scores were also significantly better. This implies that the intervention had a positive effect on the children's posture and that the effect was reflected in all aspects of the posture. It is encouraging that improvements in posture can be achieved through education and with some changes to the computer workstations. The current study identified a number of factors that would contribute to the creation of an 'ideal workstation', but due to financial constraints, only some of these could be implemented. The changes recommended by the researchers to create an 'ideal' computer workstation and the 'minimum acceptable' changes are contained in Table 4. All of the suggestions in the 'minimum acceptable' column were implemented. For example, the assessment identified that neither desks nor chairs were adjustable despite the usual variation in the anthropometrics of the paediatric users. However, the study has shown that even with minor adjustments and improved organisation and use of the workstations, an improvement in posture scores can be achieved.

Despite the improvement, the RULA scores demonstrate that none of the children have postures that could be considered to be acceptable, i.e. in Action Level 1. Previous studies that have used RULA for the assessment of children's computing posture have reported similar findings. While Oates, Evans, and Hedge (1998) and Breen, Pyper, Rusk, and Dockrell (2007) found that none of the children in their studies had 'acceptable posture', 60% were in Action Level 2. Laeser et al. (1998) also reported that children assume 'at risk' computing postures. In the pre-intervention phase of this study only 10% of the sample was in Action Level 2, with the majority in Action Level 3. However, 91% were in Action Level 2 at the post-intervention stage which although is still not in the 'acceptable' range is a significant improvement on the pre-intervention stage and is also considerably better than the findings reported by Oates et al. (1998) and Breen et al. (2007).

RULA assessments were made at three points in time during the computer class and therefore do not capture the posture of the child all of the time. However the postures that were observed were very representative of the posture of any individual child. That is, each child tended to take up a particular posture at the workstation and there was no significant variation between observations. This is also the method of use of RULA that has been described by McAtamney and Corlett (1992) who recommend the recording of “the main sequence of postures”.

4.2. Body discomfort

A baseline measurement of body discomfort was taken in order to ascertain the true effect of using a computer on the reported discomfort. Eight children reported pain before the pre-intervention class and nine reported pain before the post-intervention class, which suggests an existing level of pain among children. This finding is supported in the literature which states that there is quite a high incidence of pain among children, even those who are as young as 9 years (Perquin et al., 2000; Roth-Isigkeit, Thyen, Stöven, Schwarzenberger, & Schmucker, 2005). The intervention had a positive effect on body discomfort. In the pre-intervention stage there was a significant difference between the intensity of reported pain before and after the class, but there was no significant difference between the intensity of reported pain before and after the post-intervention class. Given that it was the ‘before’ and ‘after’ difference that was under scrutiny here and not necessarily the baseline this indicates the net discomfort which resulted from use of the computers was less during the post-intervention assessment than it was during the pre-intervention assessment.

![Mean VAS Scores Before and After Class](image-url)
4.3. Visual Display Unit (VDU) workstation

There was a significant difference between the pre and post-intervention VDU workstation checklist scores. The difference was accounted for mainly in the 'furniture' section. The reasons for this are twofold. Firstly, it was the section of the questionnaire that had scored poorest in the pre-intervention stage and therefore had the greatest potential to improve. Secondly, the intervention was not funded therefore any major alterations were not possible, but there were donations of equipment, e.g. flat screen monitor, given to the project. The changes made to the workstations were mainly organisational. For example, the computer workstation area had become a 'dumping ground' for unwanted printers, books and other equipment. The rearrangement of the work space and removal of excess and irrelevant items was carried out allowing for improved ingress and egress and also for leg clearance. The introduction of the flat screen monitor also had a positive impact on the use of the workstation as the original monitor was taking up so much space on the desk area that the keyboard could not be placed directly in front of the monitor. The keyboard was used at an angle and tended to extend beyond the edge of the desk (Fig. 3). This forced the user into a very poor working posture (Fig. 4). It is worth noting that even minor changes that did not require funding had a positive, although not ideal, effect on the suitability of the workstation for the same user (Fig. 5). Further changes will be implemented based on the recommendations made by the researchers when additional funding becomes available.

The 'computer' section of the VDU checklist also resulted in a significant difference between the pre and post-intervention scores. The improvement in these scores had largely to do with the arrangement and use of the equipment. For example, in the pre-intervention stage the researchers noticed that the keyboards were often incorrectly placed relative to the monitor therefore the child had to turn to see the
monitor. A further example was that the mouse pad and mouse were placed beyond the keypad relative to the user. These issues were remedied by moving the equipment and educating the children in its correct use.

A limitation of the study was the non-blinding of the assessors. However, the assessors were experienced, and good inter-rater reliability had been established for the outcome measures prior to the study. Furthermore, the outcomes measures were objective and specific in nature, with little scope for assessor misinterpretation or bias. The issue of blinding is difficult to address due to the nature of the study. However, the quality of the research could be improved with the inclusion of independent assessors. While the methodology did not allow for the inclusion of a randomised control trial, the authors feel that the pre-intervention phase acted as a sufficient comparison with participants acting as their own control.

5. Conclusions

The study highlights the need for continuing concern about the physical effects of children’s computer use and the implications of school-based interventions. Computer use is becoming a routine part of everyday school life. As it is still a relatively new phenomenon, it is important that children gain a rounded education in the use of computers. While it is widely acknowledged that there are numerous advantages to the user in terms of the accessibility of information, there are also ergonomic factors that need to be considered. Care must be taken to marry the benefits of computer use in schools with the optimal environment for physical and psychological comfort. Children in primary school tend to work at computers in school for relatively short periods of time yet there is evidence that even this can cause discomfort. More importantly is the fact that children are learning work practices and habits that will carry through to home computer use and through to adulthood when they will be spending considerably longer periods of time at computers.

This is one of the first studies that has conducted a school-based intervention aimed at improving posture and decreasing musculoskeletal discomfort while using computers and the results indicate that the response was quite positive. While the psychological impact of postural discomfort was not examined in this study, implementation of a programme such as the one described in this paper may contribute to increased educational productivity and satisfaction among schoolchildren. This concept needs to be examined in future research. While lack of funding limits some ergonomic adjustments, it is important to educate both teachers and children on methods to maximise the space and resources available to them. Further larger RCT’s, including collaborations from both ergonomists and educational researchers, examining schoolchildren of different ages are warranted to further explore the impact of computer use on childrens’ posture and discomfort.

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References


